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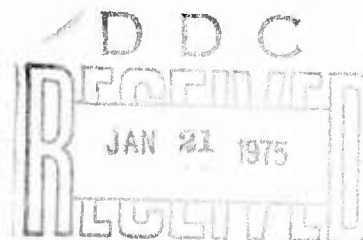
DESIGN OF A FIELD TEST FOR PROBABILITY  
OF HIT BY ANTIAIRCRAFT GUNS

HITVAL II TEST DESIGN

July 1974

*Including*  
IDA PAPER P-921

J. R. Transue, *Project Leader*



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INSTITUTE FOR DEFENSE ANALYSES  
SYSTEMS EVALUATION DIVISION



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THIRD ADDENDUM.

PAPER P-921-Add-3

DESIGN OF A FIELD TEST FOR PROBABILITY  
OF HIT BY ANTI-AIRCRAFT GUNS.

HITVAL II TEST DESIGN.

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18 WSEG, IDA/HQ

11 July 1974

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### HITVAL II TEST DESIGN

IDA Paper P-921 (WSEG Report 197)<sup>1</sup> presents a design for a test of probability of hit by antiaircraft guns (HITVAL). This test is currently being conducted at White Sands Missile Range, N.M., using four antiaircraft gun systems. It has since been decided to conduct a similar test (HITVAL II) on a fifth gun system later this year. The purpose of this addendum, then, is to present a test design for HITVAL II. ←

The test concept for HITVAL II is the same as that described in WSEG 197. Fixed- and rotary-wing aircraft make passes near the gun, which fires breakup ammunition at the aircraft. The aircraft flight paths are very accurately measured by a laser tracking system and/or cinetheodolites, while the performance of the gun system is monitored by precision instrumentation.

The factors and levels of the experimental design for HITVAL II are presented in Table 1. Three separate modes of operation of the weapon system are considered: Mode 1 involves radar tracking and radar ranging, Mode 2 involves optical tracking and radar ranging, and Mode 4 (used only in the rotary-wing trials) involves the use of a ring sight.

Four types of trials are to be performed, involving (1) a single maneuvering fixed-wing aircraft (48 trials), (2) a single fixed-wing aircraft flying straight and level (6 trials), (3) two fixed-wing aircraft flying straight and level (8 trials), and (4) a single rotary-wing aircraft (30 trials). There are thus 92 separate trials in all. The factors and levels associated

<sup>1</sup>*Design of a Field Test for Probability of Hit by Antiaircraft Guns*, IDA Paper P-921, February 1973.

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with these trials (indicated in Table 1) are similar to those described in the Second Addendum to P-921 (November 1973). The Second Addendum explains why it is desirable to use these specific factors and levels in the test, and what kinds of ordnance delivery they simulate.

The experimental design associated with these factors is presented in Table 2. The fixed-wing aircraft to be employed are the F-4 (for trials involving speeds of 500 knots) and the A-37 (300 knots), while an AH-1 COBRA is to be used in the rotary-wing trials. One replication of a full factorial design is used for all four types of trials, except that for Mode 4 of the gun system (used only in the rotary-wing trials) two replications are to be performed. Breakup ammunition should be used in all the trials, and the gun should fire up to three bursts per trial, with each burst consisting of eight rounds per tube fired.

The data elements required for the HITVAL II gun system are delineated in Table 3. They are similar (but not identical) to those required for the Flak Panzer system in the current HITVAL test, and their desired formats, relative importance, etc., are the same as for that system. (Data items for which no corresponding elements exist with the Flak Panzer system should be placed on the data tape after all the data items for which corresponding elements do exist. All data elements associated with a given time should, of course, be grouped together.)

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Table 1. FACTORS AND LEVELS FOR HITVAL II TEST

Trial Type	Mode Number	Factor	Levels				Tolerance
			1	2	3	4	
Single Fixed-Wing Aircraft, Maneuvering	1	Speed (kt) <sup>a</sup>	300	500	--	--	±10%
		Dive Angle (deg)	15	45	--	--	±10°
		Breakaway Distance (km)	1.5	--	--	--	±0.5 km
		Offset (km)/Exit Direction	0/left	0/right	1.5/away	1.5/toward	±0.5 km
	2	Speed (kt) <sup>a</sup>	300	500	--	--	±10%
		Dive Angle (deg)	15	45	--	--	±10°
		Breakaway Distance (km)	1.5	--	--	--	±0.5 km
		Offset (km)/Exit Direction	0/left	0/right	1.5/away	1.5/toward	±0.5 km
		Gun Crew No.	1	2	--	--	--
Single Fixed-Wing Aircraft, Straight and Level	2	Speed (kt) <sup>a</sup>	500	--	--	--	±10%
		Altitude (ft)	500	--	--	--	--
		Offset (km)	0	1	2	--	±0.5 km
		Gun Crew No.	1	2	--	--	--
Two Fixed-Wing Aircraft, Straight and Level	1	Speed (kt) <sup>a</sup>	500	--	--	--	±10%
		Spacing No.	1	2	3	4	--
		Gun Crew No.	1	2	--	--	--
Single Rotary-Wing Aircraft	1	Tactic	Pop-up	Moving fire	--	--	--
		Oistance (km)	1	2	3	--	±0.3 km
	2	Tactic	Pop-up	Moving fire	--	--	--
		Distance (km)	1	2	3	--	±0.3 km
	4	Gun Crew No.	1	2	--	--	--
		Tactic	Pop-up	--	--	--	--
		Oistance (km)	1	2	3	--	±0.3 km
		Gun Crew No.	1	2	--	--	--
		Replication	Two Replications for Mode 4				--

<sup>a</sup>Speed determines fixed-wing aircraft type: 300 kt - A-37, 500 kt - F-4.

Note: Where gun crew is not a factor, any competent gun crew available may be used.



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Table 2 (U). DESIGN FOR HITVAL II TEST

Fixed-Wing Maneuvering Trials						
Trial Period	Trial Ident	Gun Mode	Factor Levels			
			Gun Crew	Speed	Dive Angle	Offset
1	4101	1	-	1	1	2
	4201		-	1	1	3
	4301		-	2	1	1
	4401		-	1	2	4
	4501		-	2	2	2
	4601		-	2	2	3
	4701		-	1	2	1
	4801		-	2	1	4
2	4102	1	-	2	1	2
	4202		-	2	2	4
	4302		-	1	1	4
	4402		-	1	2	2
	4502		-	2	2	1
	4602		-	1	1	1
	4702		-	1	2	3
	4802		-	2	1	3
3	4103	2	1	2	1	1
	4203		1	1	2	4
	4303		1	2	2	2
	4403		1	2	1	4
	4503		1	1	2	1
	4603		1	1	1	2
	4703		1	1	1	3
	4803		1	2	2	3

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Table 2 (U) (Continued)

Fixed-Wing Maneuvering Trials						
Trial Period	Trial Ident	Gun Mode	Factor Levels			
			Gun Crew	Speed	Dive Angle	Offset
4	4104	2	2	1	2	4
	4204		2	1	2	1
	4304		2	2	2	3
	4404		2	2	1	4
	4504		2	2	1	1
	4604		2	1	1	2
	4704		2	2	2	2
	4804		2	1	1	3
5	4105	2	1	2	1	2
	4205		1	2	2	1
	4305		1	1	2	3
	4405		1	1	2	2
	4505		1	2	1	3
	4605		1	1	1	4
	4705		1	2	2	4
	4805		1	1	1	1
6	4106	2	2	1	2	3
	4206		2	1	1	4
	4306		2	2	1	3
	4406		2	1	2	2
	4506		2	2	2	1
	4606		2	1	1	1
	4706		2	2	1	2
	4806		2	2	2	4

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Table 2 (U) (Continued)

Fixed-Wing Straight and Level Trials					
Trial Period	Trial Ident	Gun Mode	Factor Levels		
			Gun Crew	Spacing	Offset
7	4107*	1	1	1	-
	4207*	1	1	3	-
	4307*	1	1	2	-
	4407*	1	1	4	-
	4507	2	1	-	2
	4607	2	1	-	3
	4707	2	1	-	1
8	4108*	1	2	3	-
	4208*	1	2	1	-
	4308*	1	2	4	-
	4408*	1	2	2	-
	4508	2	2	-	1
	4608	2	2	-	2
	4708	2	2	-	3
Rotary-Wing Trials					
Trial Period	Trial Ident	Gun Mode	Factor Levels		
			Gun Crew	Tactic	Distance
9	4109	1	-	2	1
	4209		-	1	1
	4309		-	2	3
	4409		-	1	2
	4509		-	1	3
	4609		-	2	2

\*These trials involve two aircraft.

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Table 2 (U). (Continued)

Rotary-Wing Trials					
Trial Period	Trial Ident	Gun Mode	Factor Levels		
			Gun Crew	Tactic	Distance
10	4110	2	2	2	3
	4210		2	2	1
	4310		2	1	1
	4410		2	2	2
	4510		2	1	3
	4610		2	1	2
11	4111	2	1	2	2
	4211		1	2	3
	4311		1	1	1
	4411		1	2	1
	4511		1	1	2
	4611		1	1	3
12	4112	4	2	-	3
	4212		2	-	2
	4312		2	-	3
	4412		2	-	1
	4512		2	-	2
	4612		2	-	1
13	4113	4	1	-	1
	4213		1	-	2
	4313		1	-	3
	4413		1	-	3
	4513		1	-	2
	4613		1	-	1

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Table 3. DATA ELEMENTS, HITVAL II GUN SYSTEM

Data Element	Data Rate	Range of Measurement	Accuracy	Remarks
Specified initial gun azimuth	once	0 to 360°	15°	Controller log
Target detection time	once	--	0.1 sec	Controller switch
Target detection mode	once	commander, gunner, radar A scope, or radar PPI	--	Controller log
Range at detection	once	--	250 m	Range TSPI <sup>a</sup>
Time at radar lock-on	once	--	0.1 sec	Event closure
MTI unit operating mode	once	operate, 1, 2	--	Controller log
Wobulation control	once	on or off	--	Controller log
Transmitter frequency	once	F1 or F2	--	Controller log
Fire control settings: Muzzle velocity correction	once	-10 to +6%	1%	Controller log
First time computer has solution	once	--	0.1 sec	Event closure
Target mask condition	10/sec	masked or unmasked	--	Controller switch
Hydraulic	10/sec	fast or slow	--	Switch position
Turret control	10/sec	semiautomatic or automatic	--	Switch position
Gunner's handgrip mode	10/sec	velocity or position	--	Switch position
Azimuth	10/sec	velocity or position	--	Switch position
Elevation	10/sec	velocity or position	--	Switch position
Fire solution indication	10/sec	on or off	--	Event closure
Fire enable	10/sec	yes or no	--	Event closure
Time of fire of each round	--	--	1 msec	Pressure Gage
Fire switch depression, upper pair	10/sec	on or off	--	Event closure
Fire switch depression, lower pair	10/sec	on or off	--	Event closure
Fire selector	10/sec	commander or gunner	--	Event closure only when there is a solution
AGC/MGC voltage	100/sec	0 to -5v (0 to -10v worst case)	0.5%	O.C. to digital
Gun angles relative to chassis:	100/sec	-2π to +2π rad	0.4 mrad	Digital encoder
Azimuth	100/sec	-0.1 to +0.5π rad	0.4 mrad	Digital encoder
Elevation (relative to turret)	100/sec			

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Table 3. (Continued)

Data Element	Data Rate	Range of Measurement	Accuracy	Remarks
Chassis orientation relative to gyro:				
Yaw	10/sec	0 to $2\pi$ rad	3.0 mrad	Resolver to digital
Pitch	10/sec	-0.1 to +0.1 rad	3.0 mrad	Resolver to digital
Roll	10/sec	-0.1 to +0.1 rad	3.0 mrad	Resolver to digital
Tilt of chassis relative to RCS: <sup>b</sup>				
Yaw	100/sec	-20 to +20 mrad <sup>c</sup>	0.33 mrad	Autocollimator
Pitch	100/sec	-20 to +20 mrad <sup>c</sup>	0.33 mrad	Autocollimator
Roll	100/sec	-20 to +20 mrad <sup>c</sup>	0.33 mrad	Autocollimator
Radar data:				
Mode switching	10/sec	footnote d	--	Event closure
Tracking azimuth (relative to turret)	10/sec	0 to $2\pi$ rad	0.5 mrad	Digital encoder
Tracking elevation (relative to turret)	10/sec	-0.1 to +0.5 $\pi$ rad	0.5 mrad	Digital encoder
Range	10/sec	-0.4 to +17.5 km	5 m	Encoder on shaft
Optical tracking data (left)				
Azimuth (relative to turret)	50/sec	0 to $2\pi$ rad	1 mrad	Digital encoder
Elevation (relative to turret)	50/sec	-0.1 to +0.5 $\pi$ rad	1 mrad	Digital encoder
Optical tracking data (right)				
Elevation	10/sec	-0.1 to +0.5 $\pi$ rad	2 mrad	Computed from gun elevation
Gunner's handgrip position				
Azimuth	50/sec	$\pm 0.25\pi$ rad	0.5%	400 Hz to digital
Elevation	50/sec	$\pm 0.25\pi$ rad	0.5%	400 Hz to digital
Fire control computer data:				
X	10/sec	-10 to +10 km	10 m	Measured output of computer X, Y, and H units
Y	10/sec	-10 to +10 km	10 m	
H	10/sec	-0.1 to +10 km	10 m	
Coasting	10/sec	yes or no	--	Event closure
Time of flight	10/sec	0 to 6 sec	0.005 sec	400 Hz to digital
Gun commands relative to gyro:				
Azimuth	10/sec	0 to $2\pi$ rad	0.4 mrad	Output of fire control computer
Elevation	10/sec	-0.1 to +0.5 $\pi$ rad	0.4 mrad	

<sup>a</sup>TSPI is time space position information (i.e., time history of position provided by range tracking instrumentation).

<sup>b</sup>RCS is the earth-fixed reference coordinate system.

<sup>c</sup>This range is likely to increase.

<sup>d</sup>Circular search (yes/no), circular search speed (fast/slow), sector search (yes/no), range autotrack (yes/no), angle mode (I, autotrack with range/II, manual), antenna scan (conical/linearly vertical), MTI (on/off), antenna pedestal controlled by commander's reflex sight (yes/no), and angle data range gating (normal/narrow).